Accelerator R&D Subcommittee
Report on SCRF and FNPL (A0) Photoinjector

H Edwards Aug 03

Based on Presentation at DOE/NSF SCRF Workshop
July 03

People-Organization

CKM Cavities	3rdHar Cavities	Photoinjector	TD/chemistry
Leo Bellantoni	Nikolay Solyak	Philippe Piot	Iouri Terechkine

Leo will speak on CKM work
Philippe and others will speak in future on experiments at photoinjector
Iouri has spoken on chemistry and Timer Khabiboulline on 3rdHar

Photoinjector-
Why these activities- Yes it is connected to LC (TESLA TTF Injector)
Experience with
- SCRF, high gradient RF
- Laser
- electrons-Space charge dominated beams
- Flat beam exp, emittance reduction and manipulation
- Other experiments- plasma, laser, gun development

Students, post docs, and Peoples fellows
Collaboration- important to be connected

Fermilab efforts on SCRF cavities & photoinjector
H Edwards

Program of last ~8years
What- introduce SCRF to FNAL
Why- SCRF R&D advances, TESLA Program, SCRF becoming enabling technology with many applications
How- Photoinjector, collaboration, CKM experiment
Progress- in cavity fabrication, photoinjector flat beam
Next Steps- 3rd harmonic cavity, high gradient operation, materials research

FNAL Current R&D Activities and Capabilities

Activities

3.9 GHz cavity development

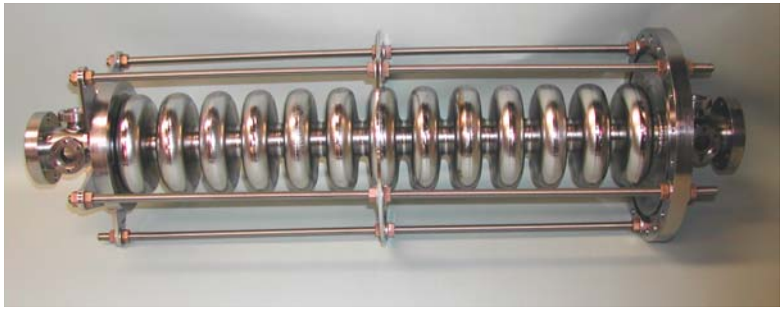
- CKM Kaon Beam Separator Cavities (transverse mode)
  L Bellantoni
- 3rd Harmonic Cavities (accelerating mode)

FNPL (A0) Photoinjector

SCRF R&D (Bauer)

Capabilities (modest, growing slowly)

- RF Design Capabilities
- Fabrication
- Tuning
- Vertical Dewar Tests
- Ultra Pure Water & Hi Pressure Rinse, Cleanroom
- Oven, up to ~1000 C
- BCP Chemistry with Argonne (under development)



CKM

3rdHar

HOM

Vertical dewar test
Temperature measurement

chemistry
development

International Collaboration (1)

History with TESLA-A collaboration over the years leading to development of SCRF expertise at FNAL and partnership in exciting and important forefront R&D.

Main Interaction-DESY, Cornell, Saclay, Orsay, INFN, UCLA

FNAL investment in collaboration

- Modulator development & construction (& IGBT)
- Cryogenic components
- Power Input couplers
- Gun and Injector components (TTF Injector II)

FNAL gain from collaboration

- SCRF information & advice, material scanning
- 200 kW klystrons
- 4MW klystron, pulse transformer, etc (Cornell)
- TESLA cavity, Cavity vacuum vessel design
- low level rf control
- Cathode Preparation Chamber
- Injection Magnets-quads & steerers (UCLA)

International Collaboration (2)

Recent Past, Present, and Future?

Investment in collaboration

- Gun exchange (last year)
- 3rd Harmonic (3rdHar) cavity prototype development

Gain from collaboration

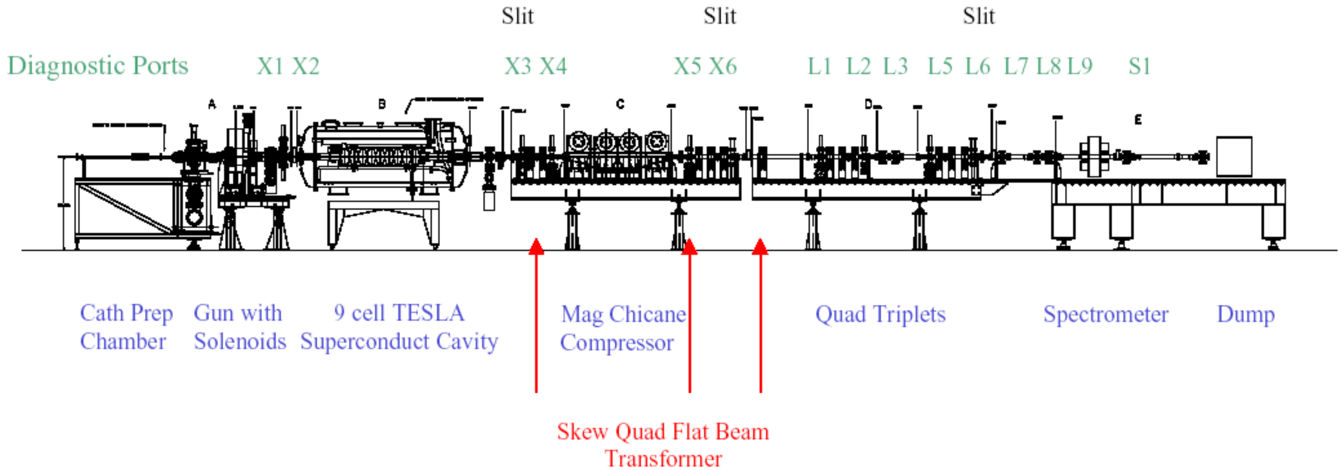
- BPM system
- RF field computational analysis and reports
- Post doc & Peoples Fellows
- Hi Gradient TESLA cavity
- Entire 8-cavity module?

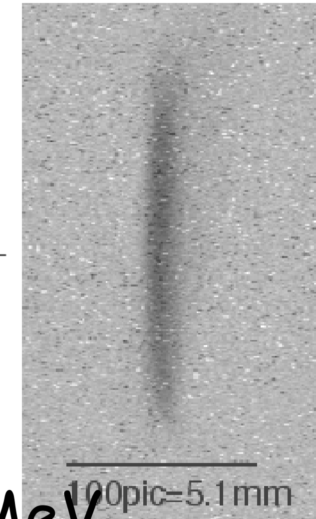
Teamwork!

- Remote operation (LBNL, DESY, Zeuthen, Michigan…)
- photoinjector R&D, Accelerator Dynamics (low emittance beams)
- Coordination of effort on cavity design, injector and TTF

US Laboratory Collaboration

Cornell, JLab-SCRF R&D information and assistance, BCP etch
Argonne-SCRF chemistry (under development)
LBL LUX-Photoinjector operation & development, flat beam also interest in both 3.9GHz cavities (CKM, 3rdHar)
Univ Wisc- basic surfaces studies
*Univ Rochester-laser, students
*UCLA- beam, plasma, students
*NIU- FNPL program students
* photoinj, not scrf





Present PhotoInjector using TESLA cavity ~15MeV

Flat Beam (new beam dynamics)

Flat Beam Exp

Space charge beams (learn to control and compensate), low emittance

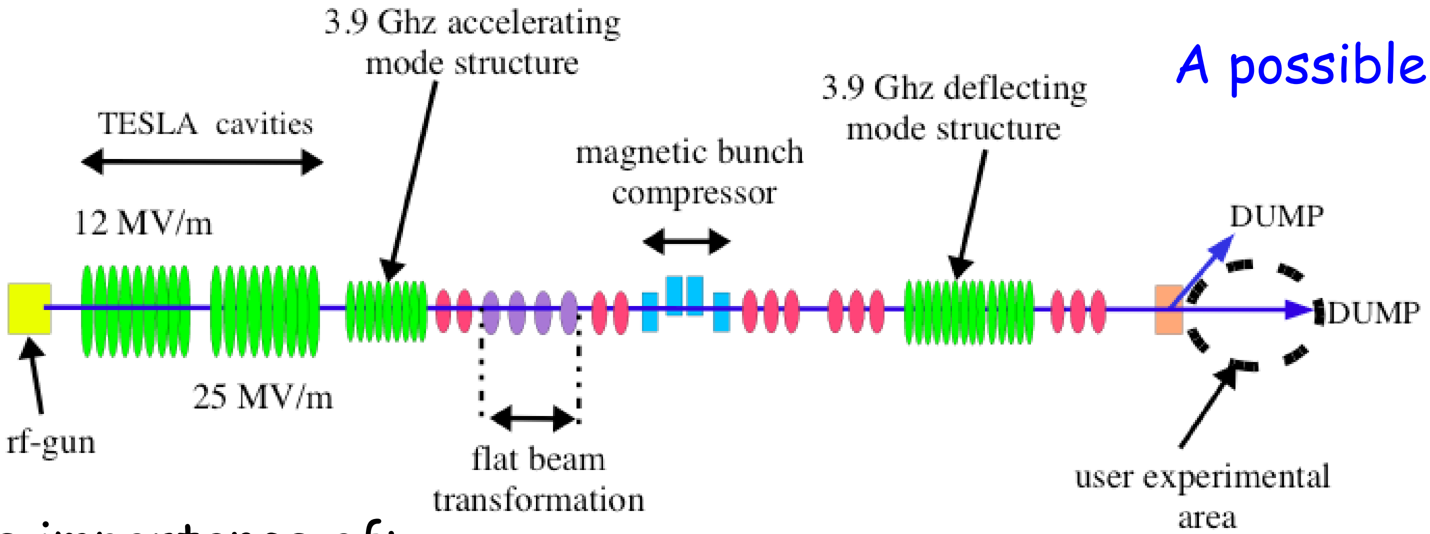
Operation of SRF system (experience)

Upgrade Plan

Install 3 new SCRF cavities: Hi Gradient TESLA, CKM, 3rdHar

- Increase energy to ~40 MeV,
- Freeze out space charge, gain experience with hi grad SRF cavity op
- Gain experience with CKM cavity in integrated system with beam, use CKM as time streak beam diagnostic
- use 3rdHar for linearization of RF to allow long to short bunch compression, minimization of 6D phase space

A possible layout



The importance of:

Hi Grad TESLA cavity- test long term operation with beam in"typical" environment (more flexibility of operation than at TTF)

CKM cavity operation- gain experience with beam & system integration, show that deflection is actually as expected

3rdHar cavity- allows for long beam bunches from gun to minimize space charge, then because the RF energy/time correlation has been linearized compression to short bunches should be possible. This R&D for the study of low emittance beams with direct application to FEL beams.

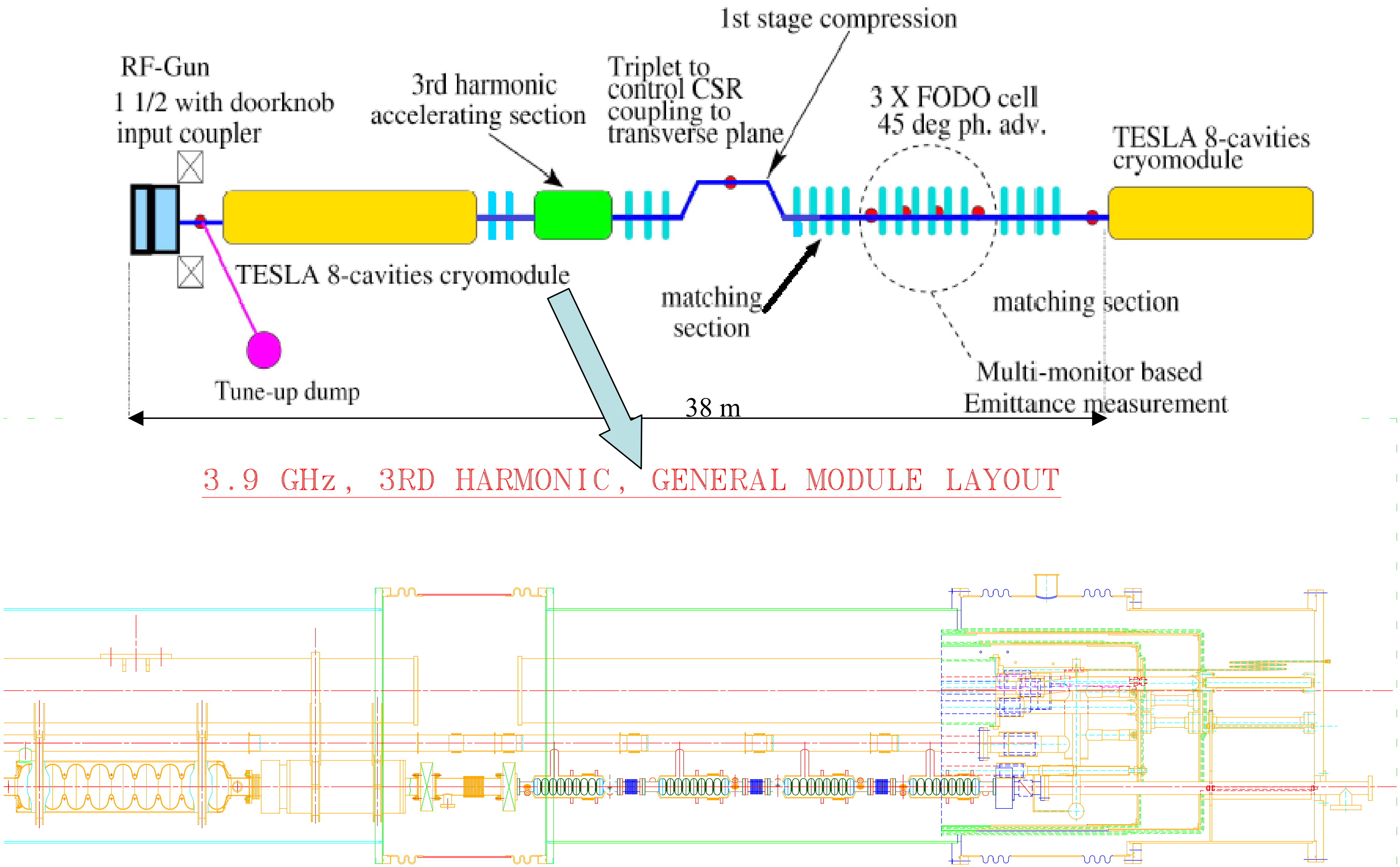
<u>Proposal</u> for a TESLA Collaboration 4 cavity 3.9 GHz Module-

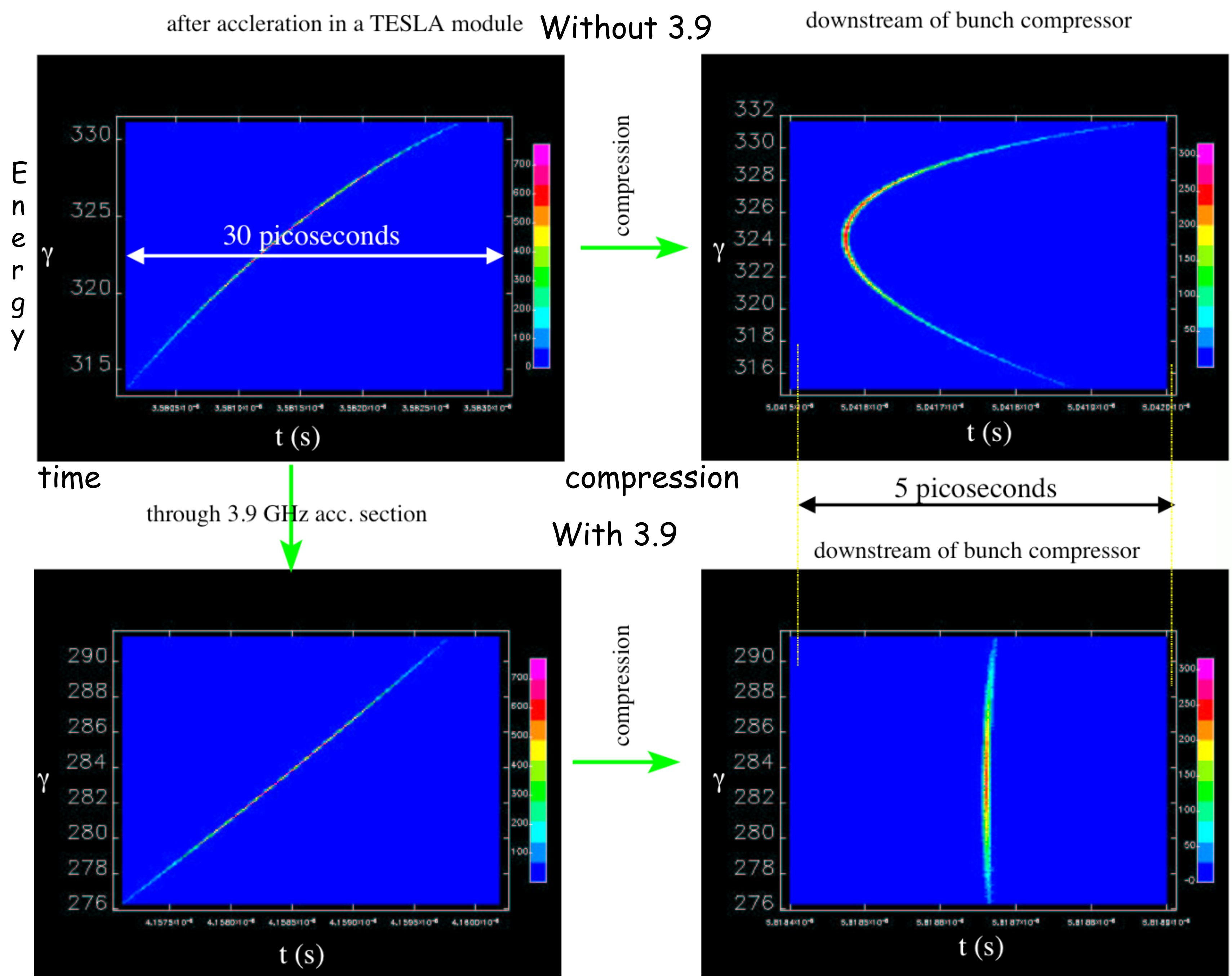
Once development of the cavity system has been accomplished for the FNPL photoinjector- Then a 4 cavity module could be built for TTFII.

This is VERY important for optimum operation of SASE
But it also gives FNAL experience with design and construction of a "module" and complete system

Other facilities are also interested in this development because of the potential for very high peak bunch currents

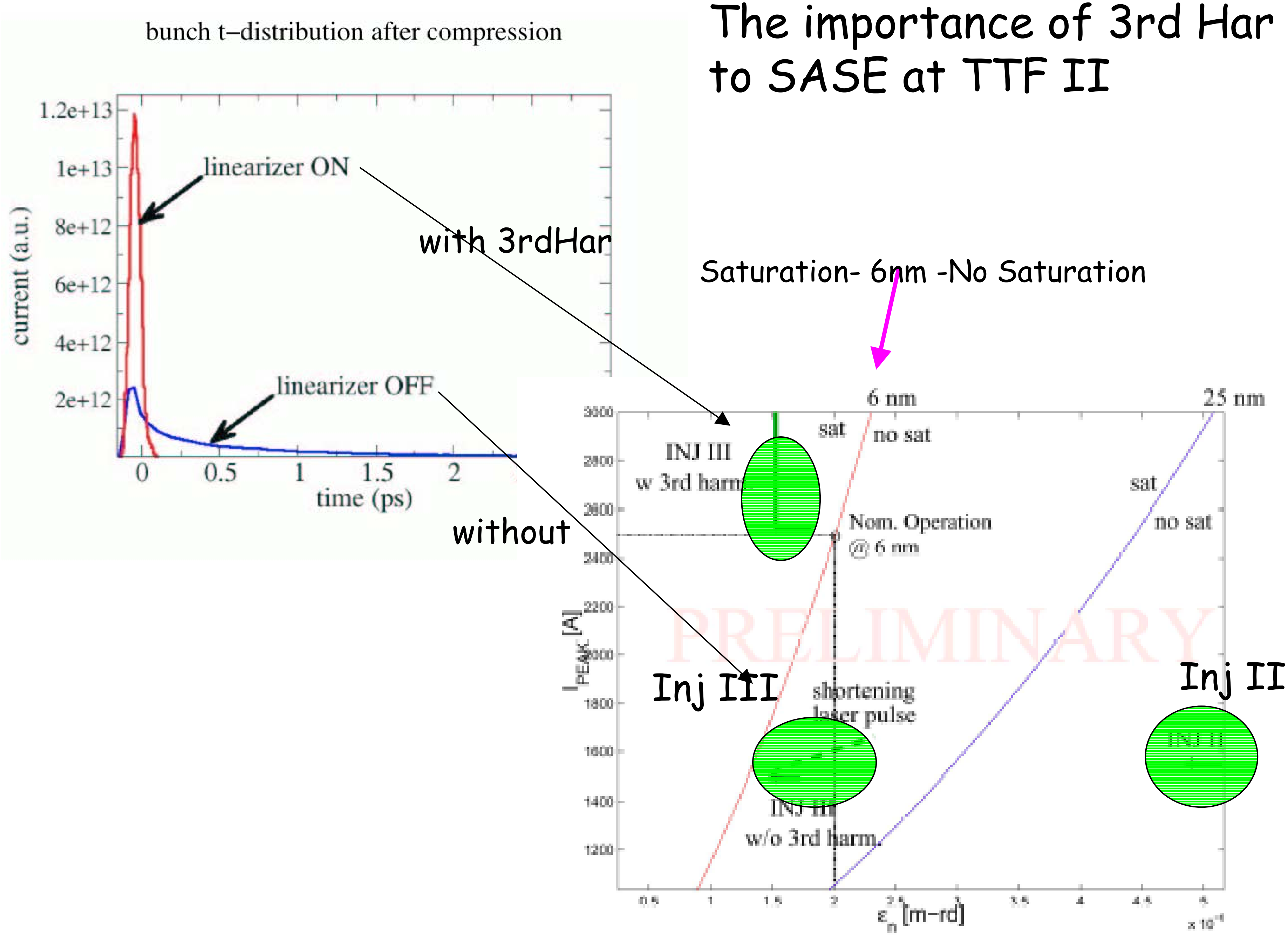
TTF Injector III with 3rd Harmonic Cavities





after accleration in a TESLA module
Without 3.9
downstream of bunch compressor
Energy
γ
30 picoseconds
t (s)
compression
time
compression
through 3.9 GHz acc. section
With 3.9
5 picoseconds
downstream of bunch compressor
compression
γ
t (s)
γ
t (s)
γ
t (s)

The importance of 3rd Har to SASE at TTF II



Applied Superconductivity Center
Univ Wisc

Task1: dc magnetization, specific heat, magneto-optical studies on Nb samples polished various ways
Goals: Find Hc1, Hc1(T) 4.2-1.5K, measure hysteresis, assess pinning effects, flux penetration in intermediate state.

Task2: assess ways to grow large grains for inter and intra grain studies of Jc. assess evidence of sc property suppression at grain boundaries

Task3: Feasibility study of using Field Emission Scanning Auger to observe chemical variations through the surface of Nb samples. Measure oxygen depth profile for different surface treatments

Memorandum **o**f **U**nderstanding FNAL – ASC/Univ Wisc

Characterize samples of high RRR Niobium for superconducting resonators (e.g. “CKM-type”) via

- DC magnetization, inter and intra-grain transport, magneto-optics;
- Auger spectroscopy (or ESCA), SEM, profilometry;

to contribute to better understanding of RF surface resistance, that is:

- revisiting classic flux motion model in view of “real” surfaces (topology related surface field enhancement, deeper flux penetration in grain boundaries,..);
- consider other mechanisms: dielectric losses, parasitic normal conducting or weakly superconducting phases in sub-oxides;

P. Bauer – Peoples Fellow – Fermilab/Tech-Division

Superconducting RF Material Research

RRR measurements on Nb samples (sample-holder for 12 samples ready);

- Proposal for high field, high power RF surface resistance measurement on “small” samples using the “sample-in-host-cavity” method (to be reviewed);
- Collaboration with UW on characterization of SCRF materials (launched recently);
- Collecting (and measuring e.g. in collaboration with universities) other SCRF material data (specific heat, conductivity,..) to support FNAL SCRF programs (ongoing);

Conclusions and Summary

Current R&D Activities and Capabilities-
•Growing expertise with a modest development program

International Collaboration- Collaboration with TESLA has been positive, and mutually beneficial-needs to be further supported in future

Critical Technical Issues- immediate need is the ability to do chemistry, leading to rapid test turnaround
•Must understand surface resistance, and achieve gradient on prototypes

Plans & possibilities in next 3 to 5 years-
•CKM & 3rdHar development for experiment and photoinjector
•Photoinjector reconfiguration with Hi Gradient, 3rdHar, & CKM
•4 cavity 3.9 GHz module for TTFII
•Possibility of injector with TESLA modules at FNAL (I still hope)

Acc technology bridges across different end use facilities
•There must be freedom/flexibility to explore the extraordinary opportunities of today's accelerator R&D.

Acc R&D Subcommittee

1) Understand the case for acc R&D- emphasis on HEP
   Fermilab role to keep HEP healthy

2) Existing R&D and evolution in future
   (excluding LC, LHC, Prot Driver R&D!)

3) need & potential for new acc R&D initiatives

4) For different funding - potential scope for future general acc R&D at FNAL

5) plan of action- enable increase in scope and effectiveness

Acc R&D Subcommittee (1)

1) Understand the case for acc R&D- emphasis on HEP Fermilab role to keep HEP healthy

Acc R&D has more wide spread applications than just HEP

It is a mistake to restrict to too narrow an end use application - ideas are generated by cross fertilization

also hadrons are not the only particles: e, mu.. lasers

There is a real revolution going on in the light source world

2) Existing R&D and evolution in future

(excluding LC, LHC, Prot Driver R&D!)

Photoinjector, SCRF cavities- are strongly connected to LC, FEL, & PD R&D

Evolution- Photoinj to 40MeV, SCRF need to prove we can do it- then get to the more basic questions - field and Q limitations

More under 3)

Acc R&D Subcommittee (2)

3) need & potential for new acc R&D initiatives

There has been discussion of HBPI at KTev, ie 1-2 TESLA modules- 200MeV, & test bed for TESLA like systems tests (ILC TRC R1,2..)

Also discussion of using KTev for PD R&D- can/should these be combined?

4) For different funding - potential scope for future general acc R&D at FNAL

Cryo plant(s) are essential

I believe an electron acc like HBPI would be less expensive than Proton test bed, could test many of same things, and would be an important systems test vehicle for TESLA like linac

5) plan of action- enable increase in scope and effectiveness????

Questions might be -

Why the FNPL Photoinjector- where is it going?

TESLA collaboration, basic acc R&D, students

Why SCRF - why not let Jlab do it?

I believe it is a core technology that FNAL needs it

I hope you will hear from or about

Philippe- A0 exp program and measurements
Markus- cold gun
Pierre- Nb surface measurements
Nick & Matt- plasma acc
YinE- flat beam
Rodion- laser acc experiment

A0 upgrade 40-50MeV mini design document

1 possible layouts and beam design
2 cavities and vessels, specifications, heat leaks, rf needs, space
3 RF ĞModulators, klystrons, llrf
4 cryo- load and system
5 electrical
6 cave and shielding- (is A0 best place? Extend outside? NWA)
7 diagnostics
8 operation, beam charactorization, justification, purpose, experiments, benefit of plan, benefit to collaboration
9 estimate of cost & schedule